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<p>(54) Title: SELF-CENTERING SYSTEM FOR A TOOL TRAVELLING THROUGH A TUBULAR MEMBER</p> <p>(57) Abstract</p> <p>A self-centering system (249) for a down hole running tool (14) is provided with four metal balls (250) equally spaced about the circumference of the tool (14). Each ball (250) is seated in a corresponding cavity (252) formed about the periphery of an upper portion (150) of the tool (14). Each cavity (252) is closed by a threaded cap (254) which has a central opening through which each ball (250) can extend. However, the diameter of the opening is less than the diameter of the ball thereby preventing the balls (250) from falling out. A pad of resilient material (256) is disposed beneath each ball (250) so as to force it radially outwardly. Due to the resilience of the pads (256), the balls are able to move between a first position in which they can contact an inner surface of a drive sub (12) and a second position radially inward of the first position. For example, in the second position the balls (250) may be flush with the external surface of the tool (14). The pads (256) are of a resilience so as to ensure substantial centering of the tool within the drive sub (12) irrespective of its inclination.</p>			

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Title

**SELF-CENTERING SYSTEM FOR A TOOL TRAVELLING  
THROUGH A TUBULAR MEMBER**

Field of the Invention

- 5 The present invention relates to a self centering system for a tool and, in particular, but not exclusively, to a self centering system for a tool used in a system for in situ replacement of cutting means for a ground drill.

Background of the Invention

- 10 A system for in situ replacement of cutting means for a ground drill is described in Applicant's International application no. PCT/AU94/00322 (WO 94/29567), the contents of which are incorporated herein by way of reference.
- 15 The system in WO 94/29567 comprises a drive sub which is adapted for connection to a lower end of a core barrel attached to a drill pipe; a tool for installing and retracting drill bit segments from the drive sub; and, an insert or bit locking sleeve for selectively locking the bit segments into seats provided about the inner circumferential surface of an end of the drive sub and subsequently releasing the bit segments for those seats.
- 20 The tool includes a main body portion and a sleeve slidably mounted thereon. Installation latch dogs provided in the tool extend from apertures or slots cut in the sleeve so as to engage the bit locking sleeve and force it into an installation position in which it locks the bit segments in a cutting position about the drive sub. The tool further includes retrieval latch dogs which can extend from different slots provided in the sleeve for engaging the bit locking sleeve and pulling it upwardly into a retrieval position in which the bit segments can be retrieved from the drive sub.
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A slidable cradle extends from a lower end of the tool for carrying the bit segments to and from the drive sub. When

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installing the bit segments, the cradle is extended from the lower end or head of the tool against the bias of a spring. Bit segments are held by rubber bands about the cradle with one end abutting a stop provided at one of the 5 cradle and an opposite end bearing against the head of the tool. When the tool is lowered into the ground drill (comprising the combination of the drill tube, core barrel and drive sub) and reaches a predetermined position within the drive sub (that being the point of engagement with the 10 bit locking sleeve), the sleeve is caused to move relative to the main body of the tool which in turn releases a set of pins holding the spring about the cradle in compression. This fires the cradle so that the spring is able to expand, retracting the cradle into the main body of the tool which 15 causes an upper end of the bit segment to slide along the head of the tool so as to extend laterally of the outer periphery of the tool. The bit locking sleeve is simultaneously pushed by the tool so as to catch the ends of and move inside the drill bit segments thereby expanding 20 the drill bit segments to the inner diameter of the drive sub and locking the drill bit segments in the cutting position.

When lowering the tool into the ground drill the tool is initially placed within a transport sleeve which acts to 25 compress the installation latch dogs to prevent catching on internal surfaces of the drill tube prior to entering a core barrel and the drive sub. A landing ring is provided between the core barrel and drill tube of a diameter which prevents further progress of the transport sleeve but 30 allows the tool to pass therethrough. The transport sleeve sits on the landing ring and, after installation or retrieval of the cutting means again carries the tool once pulled from beneath the landing ring to the surface.

Field trials of the above system have proved very 35 successful. Nevertheless, it is thought that there is a

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potential for various problems to arise under extreme operational conditions.

When the ground drill and in particular the drive sub is disposed substantially vertically within the ground, the  
5 tool is generally able to centre itself within the bit locking sleeve prior to firing. However, when the drive sub is disposed at an angle to the vertical, the tool when entering the bit locking sleeve will bear directly on an underlying portion of the sleeve and for this reason will  
10 not be generally centred within the insert. Accordingly, there is a possibility when the tool (ie. cradle) fires, that bit fingers on the upper portion of the tool may miss or not properly locate within their seat.

#### SUMMARY OF THE INVENTION

15 It is an object of the present invention to provide a system for centralising the tool within the bit locking sleeve so as to minimise the likelihood of misalignment of the bit fingers with their respective seats in the drive sub of the ground drill. However, it will be appreciated  
20 that embodiments of the present invention can be incorporated in other tools, devices and apparatuses to effect centering thereof in a conduit or tubular/hollow member.

According to one aspect of the present invention there is  
25 provided a self-centering system for an apparatus dimensioned to travel through a hollow member comprising:

a plurality of centering elements spaced about said apparatus, each of said centering elements being retained by said apparatus so as to allow movement of said centering elements between a first position wherein a remote portion of each centering element extends from said outer surface and can contact an inner surface of said hollow member, and a second position in which the remote

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portion of each centering element is nearer the centre of said apparatus than when in said first position; and,

means for resiliently biasing said centering elements from said second position toward said first 5 position, whereby, in use, when said apparatus enters said hollow member, said centering elements can contact said inner surface under the influence of said means to substantially centre said apparatus within said hollow member.

10 Preferably said remote portions comprise bearing surfaces to facilitate continued travel of said apparatus through said hollow member.

Preferably each centering element is in the form of a ball bearing.

15 Preferably said means is a pad made from a resilient material.

Preferably said centering elements are equally spaced about said apparatus.

20 Preferably said self centering system comprises three or four centering elements disposed about said apparatus.

Preferably said apparatus is a down hole running tool and said hollow member is substantially tubular.

According to another aspect of the present invention there is provided a down hole running tool for carrying a device, instrument or apparatus down a conduit said tool comprising:  
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a body adapted for connection to a running line and for carrying said device, instrument or apparatus; and

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a self centering system incorporated in or attached to said body, said self centering system comprising:

5 a plurality of centering elements spaced about said body and retained in a manner so as to allow movement thereof between a first position in which a remote portion of each centering element can extend from said outer surface and contact an inner surface of said conduit and a second position in which the remote portion is nearer the centre of said tool than when in said first position; and,

10 means for resiliently biasing said centering elements from said second position toward said first position;

15 whereby, in use, when said tool travels through said conduit said centering elements can contact said inner surface under the influence of said means to substantially centre said tool within said conduit.

**Brief Description of the Drawings**

An embodiment of the present invention will now be  
20 described by way of example only, with reference to the accompanying drawings in which:

Figure 1 is a longitudinal side view of a system for in situ replacement of cutting means for a ground drill.

Figures 1a, 1b, 1c and 1d are longitudinal section side views taken on lines a-a, b-b, c-c and d-d on Figure 1 of a system for in situ replacement of a cutting means for a ground drill in a state prior to the cutting means being locked to the ground drill and including an embodiment of the tool for transporting the cutting means to and from the ground drill;

30 Figures 2a, 2b, 2c and 2d are sectional views of the system for in situ replacement of cutting means in the ground drill but with the longitudinal-section being in a plane

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rotated 90° to that of Figures 1a, 1b, 1c and 1d;

Figures 3a, 3b, 3c and 3d are longitudinal sectional side views of the system for in situ replacement of cutting means in a ground drill in the same plane as shown in

5 Figures 1a, 1b, 1c and 1d but with the system in a second state where the cutting means are locked to the ground drill;

Figures 4a, 4b, 4c and 4d are views of the system shown in Figures 3a, 3b, 3c and 3d but in a sectional plane rotated 10 90° to that of Figures 3a, 3b, 3c and 3d;

Figure 5 is a perspective view of the tool incorporated in the system for in situ replacement of cutting means in a ground drill shown in Figures 1 to 4;

15 Figure 6 is a longitudinal-sectional view of a drive sub incorporated in the system for in situ replacement of cutting means in a ground drill which cooperates with the compression system;

20 Figure 7 is a longitudinal-sectional view of a bit locking sleeve of the system for in situ replacement of a cutting means shown in Figures 1-4;

Figure 8 is a longitudinal-sectional view of the bit locking sleeve of Figure 7 disposed within the drive sub of Figure 6;

25 Figure 9 is a longitudinal-sectional view of a portion of the system for in situ replacement of cutting means in the ground drill prior to passing through a landing ring of the ground drill;

Figure 10 illustrates the portion of the system for in situ replacement of cutting means in the ground drill shown in

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Figure 9 after passing through the landing ring; and,

Figure 11 is a view of section E-E of the tool shown in Figure 1.

Detailed Description of the Preferred Embodiment

5 In the following description, an embodiment of the tool in accordance with this invention will be described in relation to a complete system for the in situ replacement of cutting means for a ground drill. However, it is to be understood that the tool is not limited only to use in a  
10 system for the in situ replacement of cutting means in a ground drill.

Referring to the accompanying drawings, and, in particular, to Figures 1-7, it can be seen that a system 10 for the in situ replacement of cutting means for a ground drill comprises a number of separate but interactive components including a drive sub 12 (refer in particular to Figure 6) adapted for connection to a lower end of a core barrel 26 (shown in Figures 9 and 10); a installation and retrieval tool 14 (refer in particular to Figure 5) which is dimensioned to travel through the ground drill for carrying cutting means in the form of drill bit segments 16 (refer in particular to Figures 1a, 1b, 1c, 1d, 4a, 4b, 4c and 4d) to and from the drive sub 12; and, a substantially cylindrical bit locking sleeve 18 (refer in particular to Figure 7) which is slidably retained within the drive sub 12 between an installation position (shown in Figures 3a to 3d and 4a to 4d) in which the locking sleeve retains the bit segments 16 in a cutting position at the end of the drive sub 12 and, a retrieval position (shown in Figures 1a to 1d and 2a to 2d) in which the locking sleeve 18 is disposed above the end of drive sub 12 to allow the release of the bit segments 16.  
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Referring to Figure 6, it can be seen that the drive sub 12 is composed of a lower section 20 and an upper section 22 which are threadingly coupled together. An upper end of section 22 is provided with a screw thread 24 for 5 threadingly engage the core barrel 26. Moving in a downward direction from threaded end 24, it can be seen that inner circumferential surface 28 of the drive sub 12 is provided with a sequence of contiguous portions of differing diameter. Specifically, the inner 10 circumferential surface 28 includes a first portion 30 of a first diameter; a contiguous second section 32 of greater diameter; and a contiguous third portion 34 of yet greater diameter. Portion 34 extends to the end of the section 22 of the drive sub which, as previously mentioned, is 15 threaded to lower section 20. Following the third portion 34 of the inner circumferential surface 28, is a fourth portion 36 of yet greater diameter which includes the screw thread for the section 20 of the drive sub 12 enabling connection with the section 22. Contiguous with a fourth portion 36 is a fifth portion 38 of smaller diameter than portion 36 but greater diameter than portion 34. Contiguous fifth portion 38 is contiguous with a stepped up (ie greater diameter) sixth portion 40. The inner surface 28 is next provided with a seventh portion 42 which is a step wise smaller diameter than the sixth portion 40. 20 Contiguous with a seventh portion 42 is a tapered eighth portion 44 which progressively increases in diameter leading to ninth portion 46 which is of constant diameter and extends for a major length of section 20 and leads to a 25 sequence of flat and tapered surfaces shown generally as item 48 which form part of a seat 50 for the bit segments 16. The seat 50 includes a circumferential land 49 for engaging the bit segments 16 and is completed by a series of circumferentially spaced drive lugs 52 provided about inner circumferential surface 28 at a lower most end of the 30 drive sub 12. A series of circumferentially spaced apart 35

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splines 54 are bolted about the ninth portion 46 of the inner circumferential surface 28 of the drive sub'12.

The locking sleeve 18 (refer Figure 7 and 8) is in the form of a tube having a pair of peaks 56 (only one of which is shown) at an upper end 58. The peaks 56 are spaced apart and lead to a flat 60 disposed therebetween. The outer surface of the upper most part of peaks 56 is tapered radially inwardly so that that portion of the peaks 56 is spaced from the inner circumferential surface 28 (refer Figure 2c). A first circumferential recess 62 is formed about the outer surface of the insert 18 below the land 60. Spaced from the recess 62 is a second circumferential recess 64 again formed about the outer surface of the locking sleeve 18. A pair of opposing slots 66 are cut through the locking sleeve 18 and extend in the direction of the length of the locking sleeve 18. The slots 66 are located below the second recess 64. Lower end 68 of the locking sleeve 18 is provided about its outer surface with a series of splines 70 and recess 72 which engage the splines 54 of the drive sub 12 to guide the travel of the locking sleeve 18. More particularly, each spline 70 is disposed between adjacent splines 54 with each spline 54 able to ride within a corresponding recess 72. This arrangement allows the locking sleeve 18 to slide along the inner circumferential surface 28 but prevents rotation of the locking sleeve.

The tool 14 comprises a main body portion 74 and an outer sleeve 76 slidably mounted on the main body 74. An upper end of the main body 74 is threadingly connected via coupling 78 to a pivotal spear point 80. The spear point 80 is well known in the industry and facilitates coupling of the tool 14 to a running line (not shown). The main body 74 is itself composed of a first portion 82 and a second portion or head 84 which, as will be explained in greater detail below, are retractably coupled together.

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- Housed within a cavity 86 of the main body 74 is a latching mechanism 88 known as "installation latch dogs". The installation latch dogs 88 essentially comprise a pair of arms 90 which are pivotally coupled together at one end by a pin 92 and biased by a spring 94 at an opposite end so as to extend from the outer surface 96 of the tool. Opposite ends of the pin 92 pass through respective slots 98 formed in the main body 74 and into diametrically opposed holes 100 formed in the sleeve 76. This provides a slidable connection between the sleeve 76 and main body 74 as, when sleeve 76 moves longitudinally relative to the main body 74, the pin 92 is able to slide within slots 98. Pin 92 is held in place by a snap ring 102 which is disposed within a circumferential recess 104 formed about the outer periphery of the sleeve 76. To assist in locating the snap ring 102 about the pin 92 opposite ends of the pin are also provided with grooves 106 within which the snap ring 102 can sit. Snap ring 102 is basically in the form of a metal wire ring which is resiliently expandable.
- The end of the arms 90 which extend from the cavities 86 are provided with a planar latching face 108 for engaging the lands 60 of the locking sleeve 18. A central part of the spring 94 is wound about a stud 110 which resides wholly within the main body 74 and held at its opposite ends in diametrically opposed slots 112.

A second latching mechanism 114, known as "retrieval latch dogs" are also located within the cavity 86. The retrieval latch dogs 114 comprise a pair of arms 116 which are disposed in the same plane as arms 90 of the installation latch dogs but are orientated in the opposite direction. The arms 116 are pivotally coupled together at a lower end about a pin 118 which threadingly engages and is wholly disposed within the main body 74. An opposite end of each arm 116 is biased by spring 120 so as to move out of the cavity 86 toward contact with an inner surface of the

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locking sleeve 18. A central part of the spring 120 is wound about and retained by stud 122. Opposite ends of the stud 122 are held within diametrically opposed slots 124 formed in the main body 74. The end of arm 116 opposite the pin 118 is provided with a latching face 125 for engaging respective slots 66 in the locking sleeve 18. Adjacent an end of the latching face 125 nearest the sleeve 76 is a bevelled face 126 which slopes away from the centre of the tool 14 in the direction toward pin 118. The bevelled face 126 then leads to a straight face 128 on the rotary outer side of each arm 116 which in turn leads to a second bevelled face 130 sliding toward the centre of the main body 74. A releasable pin 132 is provided which can pass through both the arms 116 to lock the retrieval latch dogs 114 in a substantially compressed state so as to be disposed within the confines of the main body 74. Pin 132 is held in place by a snap ring 133. This pin is inserted when the tool 14 is used in an installation mode to install the bit segments 16 into the drive sub 12, and removed when the tool 14 is in a retrieval mode for retrieving the bit segments 16 from the drive sub 12.

The lower end of the first portion 82 of the main body 74 is formed with a tubular extension 134 which receives a spigot 136 extending from upper end of the second portion 84. A pin 138 extends transversely through the tubular extension 134 and resides within opposing slots 140 formed in the spigot 136 intermediate the length of the tubular extension 134. A pair of diametrically opposed holes 142 is formed in the tubular extension 134 for seating respective ball bearings 144. There is a stepped reduction in the internal diameter at the lower end of tubular extension 134 so as to form a cup-like structure 146.

A pair of diametrically opposed elongate slots 148 is formed in the spigot 136 below the holes 142. The slots 148 receive the ball bearings 144 but are of a width so as

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to allow only a portion of the ball bearings 144 to extend therethrough, preventing the ball bearings 144 from passing wholly therethrough. The elongation of slots 148 allows relative movement of the spigot 136 and tubular extension 134 to facilitate movement of the head 84 relative to the first portion 82 of the tool.

An upper portion 150 of the head 84 is of a substantially cylindrical shape but has peripheral longitudinal channels 152 (refer Figure 5) provided along the side thereof for allowing the flow of liquid such as water and drilling mud. Adjacent the upper portion 150 is an intermediate portion 154 of constant but reduced diameter. Contiguous with the intermediate portion 154 is a bottom portion 156 of substantially frusto-conical shape which narrows in the downward direction. A plurality of ramps 158 are disposed radially about the outer surface of the bottom portion 156 for seating an upper end 160 of the bit segments 16. Each ramp 158 is bound by opposing side walls 162 between which the upper ends 160 of the bits segments 16, lie. Longitudinal channels 164 are also formed centrally of each ramp 158 to allow the flow of water and drilling mud. Similarly, channels 166 are formed between adjacent side walls 162 of adjacent ramps 158 again to allow for the flow of water and drilling mud.

A spring 168 is disposed about the spigot 136 and has an upper end seated in the cup-like structure 146 and a lower end bearing against an upper face 170 of the upper portion 150 of the head 84. The spring 168 is biased so as to push the head 84 and first portion 82 of the tool apart in a longitudinal direction.

Lower end 172 of the sleeve 76 is also biased in a direction so as to contact the face 170 on the head 84. This bias is provided by a coil spring 174 disposed about

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an upper portion of the main body 74 between the coupling 78 and an upper end 176 of the sleeve 76.

Cradle 178 passes through an axial hole 180 formed in the head 84 so that an upper portion of the cradle 178 is disposed within the spigot 136. The purpose of the cradle 178 is to hold the bit segments 16 during transport to and from the drive sub 12 and, when installing the bit fingers 16, to expand the upper end 160 of the bit fingers radially outwardly so that they can be collected by the locking sleeve 18.

A coil spring 182 surrounds an upper end of the cradle 178 disposed within the spigot 136. The spring 182 is retained on the cradle 178 by a washer 184 fixed to the cradle 178 by a bolt 186. When the tool 14 is being used to install bit segments 16 into the drive sub 12 (as shown in Figures 1a to 1d and 2a to 2d) the cradle 178 is extended from the head 84 so as to compress the spring 182. Spring 182 is held in compression by the ball bearings 144 which engage an upper surface of the washer 184 through the longitudinal slots 148.

Disk-like flange 188 extending in a plane transverse to the axis of the tool 14 is attached by a nut 190 to the bottom end of the cradle 178. An upper face of the flange 188 acts as a bearing face for cutting face 192 formed at a lower end of the bit segments 16. The bit segments 16 are held circumferentially about the cradle 178 by three elastic bands 194 extending around the cradle 178 about the outer surfaces of the bit segments.

An upper end of the tool 14 is provided with a locking system 196 for selectively locking the sleeve 76 to the main body 74 preventing relative sliding motion. The locking system 196 includes a pair of diametrically opposed recesses 198 formed in the main body 74. The recess 198

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are designed to capture locking members in the form of ball bearings 200. Disposed within the main body 74 is a biasing system 202 designed to act on the ball bearings 200 so as to force them radially outwardly. The biasing system 5 202 comprises a pair of cups 204 which are dimensioned so as to be able to slide within the recesses 198 and which between them retain a coil spring 206. The cups 204 and spring 206 are in turn disposed within a cylindrical casing 208 which extends transversely across cavity 86 in the main 10 body 74 coaxially with the recesses 198. The casing 208 essentially seals the spring 206 from drilling fluids within which the tool 14 operates. A channel 210 extends from each recess 198 longitudinally about the outer surface of the main body 74. The channels 210 provide a race 15 within which the ball bearings 200 may travel when they are able to escape their respective recesses 198.

The locking system 196 also includes a pair of diametrically opposed openings 212 of a diameter less than the maximum diameter of the ball bearings 200 and formed at 20 an upper end of the sleeve 76. The ball bearings 200 are biased by the biasing system 202 so as to extend through the openings 212 and bear against the inner circumferential surface 28 of the drive sub 12.

Moving in the downward direction from the openings 212, the 25 sleeve 76 is provided with a pair of diametrically opposed longitudinally extending slots 214 through which the arms 90 of the installation latch dogs 88 can extend. The arms 90 are biased to extend through the slots 214 by the spring 94.

30 As best seen in Figure 9, a compression system 216 is provided about the sleeve 76 and slots 214 for releasably retaining the installation latch dogs 88 within the confines of the outer surface of the tool 14. The compression system 216 includes a ring-like member in the

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form of a snap ring 218 which is adapted for location about the installation latch dogs 88. The snap ring 218 is able to be pushed or moved between two spaced apart grooves 220 and 222 to form circumferentially about the outer surface of the sleeve 76 and across the slots 214. The groove 220 takes the form of a substantially U-shaped channel having a substantially upright bank 224 at a side nearest the groove 104 and an opposing sloping bank 226 which is inclined away from groove 104.

5      Groove 222 is also in the form of a channel having a sloping bank 228 on the side nearest and sloping toward groove 220. An opposite side of the groove 220 has an upright bank 230. The groove 220 is deeper than groove 222. Also, the groove 220 is disposed about a portion of 10     slots 214 through which the arms 90 do not extend while, groove 222 is disposed about a part of the slots 214 through which the arms 90 can extend.

15     The compression system 216, and more particularly the snap ring 218 is adapted to cooperate with a substantially stepped surface provided inside the drill pipe. This stepped surface is provided by a conventional landing ring 232 which is screwed into the ground drill between the core barrel 26 and drill pipe 234. When the tool 14 is being lowered through the drill pipe to transport the bit segments 16 to the drive sub 12, the installation latch dogs 88 are initially held in a relatively compressed state by the snap ring 218 located within groove 222 to ensure that the tool can pass through the landing ring 232. As shown in Figure 9, when the snap ring 218 is in groove 220, 20     the latching faces 108 of the arms 90 are disposed within the outer surface of the tool 14 so that they cannot engage the landing ring 232. However, the snap ring 218 has an upper portion which sits proud of the outer surface of the tool 14 and is contacted by and temporarily held against 25     the landing ring 232. Due to the momentum of the tool 14

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it continues to move in a downward direction and the snap ring 218 is expanded radially outwardly against the sloping banks 228 as the tool continues its downward movement. When the snap ring 218 is knocked out of the groove 222,  
5 the arms 90 are able to expand from the slots 214 by action of the spring 94 (refer Fig 10). With the tool continuing to move in the downward direction, the groove 220 eventually underlies the snap ring 218 and, due to the resilient expansion of the snap ring 218, it can then  
10 compress into the groove 220 as shown in Figure 10. The groove 220 is of a depth such that when the snap ring 218 is located therein, it is able to pass through the landing ring 232.

A second pair of longitudinally extending slots 235  
15 extending collinearly with and disposed below the slots 214 is provided in the sleeve 76 for allowing the retrieval latch dogs 114 to expand therethrough and contact the inner surface of the locking sleeve 18. An upper end of each slot 235 is provided with a bevel 236 formed between the  
20 radially inner and radially outer circumferential surfaces of the sleeve 76 which, when looking in the upward direction, slope in a mutually converging manner.

As will be explained in greater detail below, the combination of the slots 235 formed in the sleeve 76 and  
25 the spring 174 co-act to form a retraction system for retracting the retrieval latch dogs into the cavity 86 during extraction of the tool 14 after retrieving a set of bit segments 16 from the drive sub 12.

Below the slots 235 in the sleeve 76 is a pair of elongated holes 238 which allow access to the pin 138 for removal and installation. By removing the pin 138, the head 84 can be detached from the first portion 82 of the tool 14 for serving and maintenance.  
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A lower portion 240 of the sleeve 76 near the end 172 fits over the tubular extension 134 of the main body portion 82. An upper length 242 of the lower portion 240 has an internal diameter arranged so that when the upper length 242 is located over the holes 142, it pushes the ball bearings 144 through the underlying slots 148 so as to be able to contact the washer 184. However, a lower length 244 of the lower portion 240 has increased in the diameter so as to provide a gap 246 between the outer circumferential surface of tubular extension 134 and the inner circumferential surface of the lower length 244. As explained in greater detail below, when the sleeve 76 slides backwardly relative to the main body 74, the ball bearings 144 are able to move into the gaps 246 out of contact with the washer 184 to allow expansion of the spring 182 and subsequent retraction of the cradle 178 into the head 84.

Figure 8 shows the locking sleeve 18 in an installation position. As previously mentioned the moved locking sleeve 18 can be moved between the retrieval position shown in Figures 1a to 1d and 2a to 2d and an installation position as shown in Figures 3a to 3d, 4a to 4d and 8, by the tool 14. As shown in Figure 8 the locking sleeve 18 is held in the installation position by a snap ring 248 located in a void between the first recess 62 and the sixth portion 40 of the inner circumferential surface 28 of the drive sub 12. Snap ring 248 is always maintained within the sixth portion 40. When the locking sleeve 18 is pulled to the retrieval position by the tool 14, the snap ring 248 expands out of recess 62 and subsequently collapses into the second recess 64 holding the locking sleeve in this position until the tool 14 is again lowered to insert new bit segments 16, (as shown in Figures 1a to 1d and 2a to 2d).

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A self centering system 249 for centering the tool 14 within the locking sleeve 18 as shown generally in figure 11. The self centering system is disposed circumferentially about the tool 14 in a transverse plane taken through upper portion 150 of the head 84. The self centering system is provided with a plurality, in this case four, centering elements in the form of metal balls 250 such as used in ball bearings, equally spaced about the circumference of the tool 14. Each ball 250 is seated in a corresponding cavity 252 formed about the periphery of the upper portion 150. The cavities 252 are closed by a threaded cap 254 which has a central opening through which a ball 250 can extend. However, the diameter of the opening is less than the diameter of the ball thereby preventing the ball 250 from falling out of the cavity 252. Balls 250 are resiliently retained within the cavities 252 by a pad of resilient material 256 disposed beneath each ball so as to force the ball radially outwardly. Due to the resilience of the pads 256, the balls are able to move radially between a first position lying on an imaginary circle subscribed about the head 84 having a diameter equal to or greater than the inner diameter of the locking sleeve 18 and a second position substantially flush with the outer surface of upper portion 150. That is, in the first position the balls 250 extend from the outer surface 150 and contact the inner surface of the sleeve 18. In the second position the balls 250 are pushed toward the centre of the tool 14. The pads 256 are of a resilience such that when the tool 14 is within the sleeve 18 both lying in a horizontal plane, the pads can support the weight of the tool or at least the head of the tool to ensure substantial centering of the tool within the locking sleeve 18.

Although not shown, a substantially identical centering system can be provided about the midlength of the tool 14. In this instance, slots will be required along the sleeve 76 in order to provide for the required relative sliding

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motion of the sleeve 76 and main body 74 during the operation of the tool 14.

As explained in greater detail below, when the tool 14 is used to retrieve bit segments 16 it is necessary to lock 5 the cradle 178 in an extended position. This is achieved by removing pin 132 from the retrieval latch dogs and inserting it through cradle locking hole 260 formed through the intermediate section 154 of the head 84. The cradle 178 is also provided with a hole 262 for alignment with the 10 locking hole 260 through which the pin 132 can pass. Pin 132 is held in place by the snap ring 133 placed about the outer periphery of the intermediate section 154.

The operation of the system 10 will now be described.

When initially installing segments 16 in the drive sub 12, 15 the ball bearings 200 are located within the recesses 198, the cradle 178 extended from the head 84 so that the spring 182 is compressed and locked in a compressed state by the abutment of the ball bearings 144 with the washer 184, and the bit segments 16 loaded on the cradle 178 and held in 20 place by the rubber bands 194. The installation latch dogs 88 held in a relatively compressed state by the snap ring 218 being disposed within the groove 222 (as shown in Figure 9). As the retrieval latch dogs 144 play no part in the installation of the bit segments 16, they are also 25 locked in a relatively compressed state by pin 132 and corresponding snap ring 133. The locking sleeve 18 is held in the retrieval position by snap ring 248 residing in a void between the second recess 64 and the sixth portion 40 of the inner circumferential surface 28 of the drive sub 30 12. The tool 14 is lowered through the drill pipe by a wire line attached to the spear point 80. The ball bearings 200 are held within the recesses 198 against the inner circumferential surface of the drill pipe, thereby locking the sleeve 76 against sliding relative to the main

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body 74, this prevents accidental or premature firing of the cradle 178.

Referring to Figures 9 and 10, as the tool 14 passes through the landing ring 232, the snap ring 218 held initially within the groove 222 is pushed along the sleeve 76 to snap back into the groove 220. When in this groove, the snap ring 218 radially compresses so as to pass through the landing ring 323. The ball bearings 200 are also able to pass through the landing ring 323 by being compressed further into their recesses 198 against the bias of the spring 200.

Latching faces 108 of the installation latch dogs 88 contact the peaks 56 of the locking sleeve 18 causing the tool 14 to rotate about its longitudinal axis. This correctly orientates the bit segments 16 with the seat 50 and in particular drive lugs 52. As the tool continues to move downwardly, but prior to engagement of the latching faces 108 with the lands 60 of the locking sleeve 18, the ball bearings 200 enter the second portion 32 of the inner circumferential surface 28 of the drive sub 12. The second portion 32 has a greater inner diameter than portion 30 immediately above it, and therefore by action of the bias applied by spring 206, the ball bearings 200 are lifted out of their recesses 198 by the spring 206. Indeed, the spring 206 pushes the cups 204 to a position so that the surface thereof immediately below the ball bearing 200 is substantially coplanar with the channel 210. At this point, the sleeve 76 and main body 74 are decoupled to the extent that the sleeve 76 is now able to slide relative to the main body 74.

The tool 74 then continues its downward travel until the latching faces 108 engage the lands 60 of the locking sleeve 18. This contact causes the main body 74 to continue to move forward relative to the sleeve 76

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compressing the spring 174. Also, the ball bearings 144 move into the gap 246 between the lower length 244 of the sleeve 76 and the outside of the cup-like structure 146 of the portion 82 (refer Figures 3 and 4). The ball bearings 144 can now be pushed radially outwardly by the backward bias supplied to the washer 284 by the compressed spring 182. This frees the spring 182 to expand retracting the cradle 178 into the head 84. As a result, upper ends 160 of the bit fingers 16 slide along the ramps 158 of the head 84 so as to extend laterally from the tool. The ends 160 are collected by the lower end of the locking sleeve 18 which moves behind the bit fingers 16 and spreads the bit fingers radially outwardly. The locking sleeve 18 moves in this manner by virtue of the continued downward movement of the tool 14 which by its latch dogs 88 engage the locking sleeve 18 pushing it downwardly.

While the tool 14 is in the locking sleeve 18, or at least the head 84 is in the sleeve 18, the self-centering system 249 maintains the tool 14 substantially centered in the sleeve 18, irrespective of the inclination of the drive sub or locking sleeve 18.

The bit fingers 16 engage the seating land 49 preventing any further downward movement thereof. The head 84 of the tool is prevented from falling at the bottom of the drive sub 12 by virtue of abutment with a stop in the form of a radially inner surface of the bit fingers 16. However, the first portion 82 of the main body 74 is still able to travel a short distance due to the nature of the coupling between the head 84 and the first portion 82. As seen most clearly in Figures 1 and 2, a gap exists between the surface 170 and the end of the cup-like structure 146. The first portion 82 is able to continue moving in the downward direction by a distance equal to that gap. In effect, the head 84 retracts into the first portion 82. This retraction allows the tool 14 and in particular, the first

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portion 82 to push the locking sleeve 18 fully home onto a landing seat formed by the inner surfaces of the bit finger 16.

With the bit fingers 16 now installed in the cutting 5 position, the tool 14 can be pulled upwardly and retracted from the drive sub 12 and drill string.

In order to retrieve the segments 16 for replacement, the snap ring 133 and pin 132 which maintain the retrieval latch dogs 144 in a compressed state are removed. This 10 allows the retrieval latch dogs 144 to move in an outward direction in compliance with the bias supplied by the string 120. However, the pin 132 is now reinserted into the cradle locking hole 260 so as to lock the cradle 178 in a fully extended position. Of course, as it is now desired 15 to retrieve the bit segments 16, no bit segments are initially located onto the cradle 178 when lowering the tool 14 into the drill pipe. The remaining configuration of the tool remains the same as for when stalling the bit segments 16. As the tool is passed through the landing 20 ring 232, the snap ring 218 is moved from groove 222 to groove 220 allowing the installation latch dogs to extend from the slots 214. Again, the installation latch dogs 88 contact the peaks 56 causing the tool 14 to rotate so as to correctly orientate the bit 84 and cradle 176 to receive 25 the bit segments. Additionally, when the ball bearings 200 enter the second portion 32 of the inner surface of the drive sub 12, they are moved out of their respective recesses 198 and are able to then ride along the channels 210 facilitating relative sliding motion of the sleeve 76 and main body 74. When the tool 14 has bottomed out with 30 the head 84 abutting the inner surfaces of the bit fingers 16, the retrieval latch dogs 114 extend through slots 235 in the sleeve 76 and into the slots 66 of the locking sleeve 18. When in this configuration, the bevelled face

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126 of each arm 116 also bears against the ninth portion 46 of the inner circumferential surface of the drive sub 12.

As the tool 14 is now pulled upwardly by a wire line attached to the spear point 80, the latching faces 120 engaged in the slots 66 pull the locking sleeve 18 upwardly thereby releasing the bit segments 16. The bit segments 16 collapse onto the cradle 18 by action of the rubber bands 194.

In order to now fully withdraw the tool 14 and bit segments 16, the retrieval latch dogs 114 must now be disengaged from the slots 66 of the locking sleeve 18. This is achieved by a retraction system which includes the inner surface 28 of the drive sub 12 as well as the slots 234 of the sleeve 76. In particular, as the tool 14 is being dragged upwardly, the bevelled faces 126 and flat faces 128 contact the sloping ninth portion 44 of the inner surface of the drive sub 12 which pushes the arms inwardly toward each other. At the same time, the spring 174 is pushing the sleeve 76 in a downward direction. The arms 116 are pushed inwardly by the sloping ninth portion 44 inner surface of the drive sub 12 to an extent such that the bevelled faces 126 can be brought into contact with the bevels 236 at the top of the slots 235. The force of the spring 174 and the relative configuration of the bevelled face 126 and bevels 236 pushes the sleeve 76 over the retrieval latch dogs disengaging them from the locking sleeve 18.

If for some reason the sleeve 76 cannot be pushed by the spring 174 alone over the retrieval latch dogs, upon continued upward pull on the tool 14, the ball bearings 200 engage the boundary between the first and second surface portions 30 and 32 of the drive sub 12 and maintain the sleeve 76 in a static position while rolling along channels 214. Accordingly, the force of the pull on the tool 14 is

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transmitted to the sleeve 76 to push it over the retrieval latch dogs 114. The ball bearings 200 then collapse into their recesses 198 compressing the spring 200 so as to allow full retraction of the tool 14.

- 5 The tool can then be withdrawn from the drill string, the bit segments 16 taken off the cradle and a fresh set of drill bits 16 loaded on to the cradle for installation into the drive sub.

Now that an embodiment of the self-centering system has been described in detail, it will be apparent to those skilled in the relevant arts that numerous modifications and variations may be made without departing from the basic inventive concepts. For example, the resilient pads 256 can be replaced with other biasing means such as springs in order to bias the balls 250 radially outwardly. Additionally, the balls 250 may be replaced with other elements adapted to extend from the cavity 254 and having a bearing face on its radially outermost end for bearing against the inner circumferential surface of the locking sleeve 18. Further, while the centering system 248 is shown as having four centering elements (ie. ball bearings) disposed about the periphery of the tool 14, it may include more or fewer centering elements. Finally, the balls 250 may be made from a material other than metal.

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All such modifications and variations are deemed to be within the scope of the present invention, the nature of which is to be determined from the foregoing description and the appended claims.

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THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:-

1. A self-centering system for an apparatus dimensioned to travel through a hollow member comprising:  
5        a plurality of centering elements spaced about said apparatus, each of said centering elements being retained by said apparatus so as to allow movement of said centering elements between a first position wherein a remote portion of each centering element extends from said outer surface and can contact an inner surface of said hollow member, and a second position in which the remote portion of each centering element is nearer the centre of said apparatus than when in said first position; and,  
10      means for resiliently biasing said centering elements from said second position toward said first position, whereby, in use, when said apparatus enters said hollow member, said centering elements can contact said inner surface under the influence of said means to substantially centre said apparatus within said hollow member.
- 20 2. A system according to claim 1, wherein said means is a pad made from a resilient material.
3. A system according to claim 2, wherein said centering elements are equally spaced about said apparatus.
- 25 4. A system according to claim 3, wherein said remote portions comprise bearing surfaces to facilitate continued travel of said apparatus through said hollow member.
5. A system according to claim 4, wherein each centering element is in the form of a metal ball.

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6. A system according to claim 5, wherein said self centering system comprises three or four centering elements disposed about said apparatus.

7. A system according to claim 6, wherein said apparatus is a down hole running tool and said hollow member is substantially tubular.

8. A down hole running tool for carrying a device, instrument or apparatus down a conduit said tool comprising:

10 a body adapted for connection to a running line and for carrying said device, instrument or apparatus; and  
a self centering system incorporated in or attached to said body, said self centering system comprising:

15 a plurality of centering elements spaced about said body and retained in a manner so as to allow movement thereof between a first position in which a remote portion of each centering element can extend from said outer surface and contact an inner surface of said conduit and a second position in which the remote portion is nearer the centre of said tool than when in said first position; and,  
means for resiliently biasing said centering elements from said second position toward said first position;

25 whereby, in use, when said tool travels through said conduit said centering elements can contact said inner surface under the influence of said means to substantially centre said tool within said conduit.

9. A tool according to claim 8, wherein said means is a pad made from a resilient material.

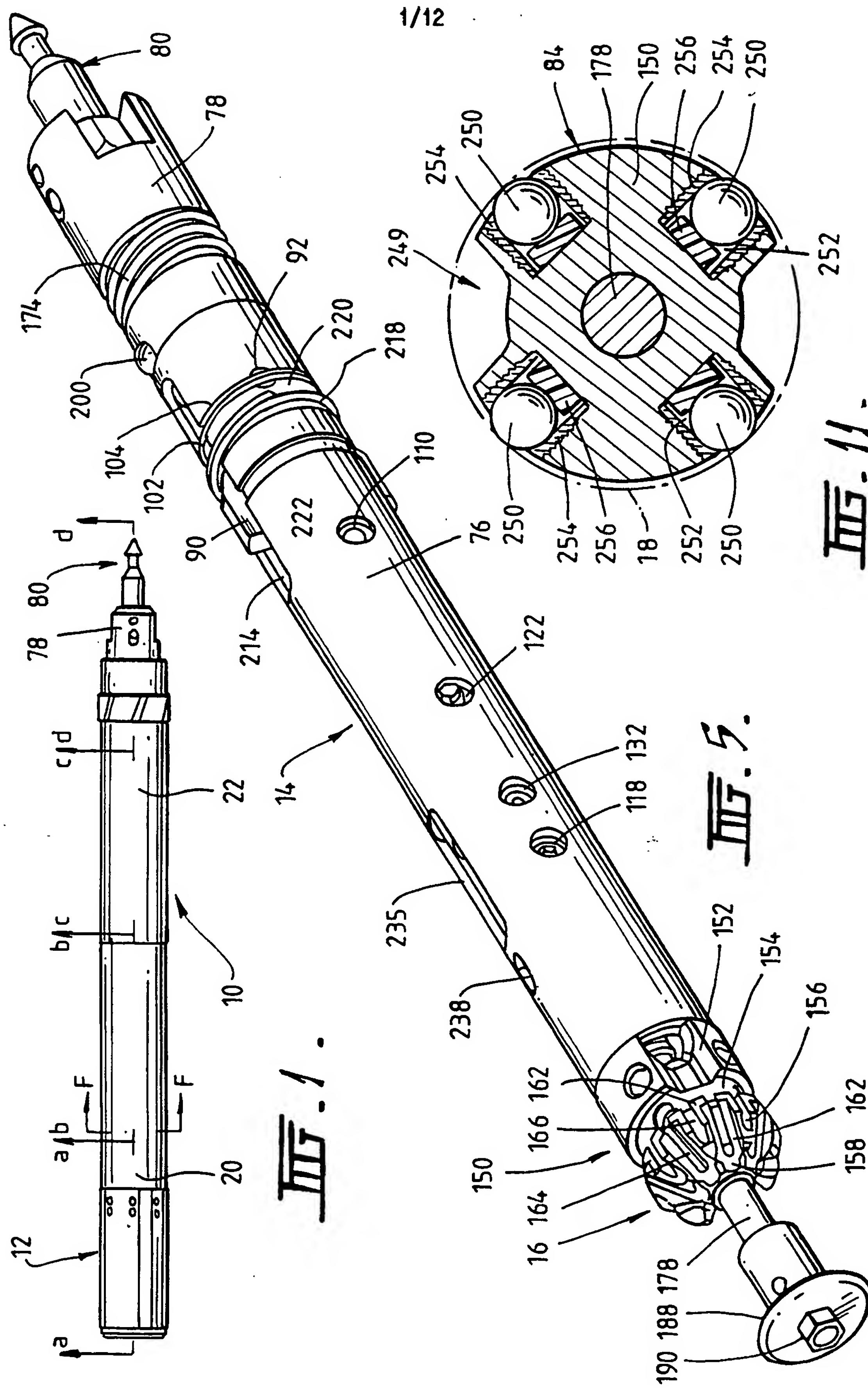
30 10. A tool according to claim 9, wherein said centering elements are equally spaced about said apparatus.

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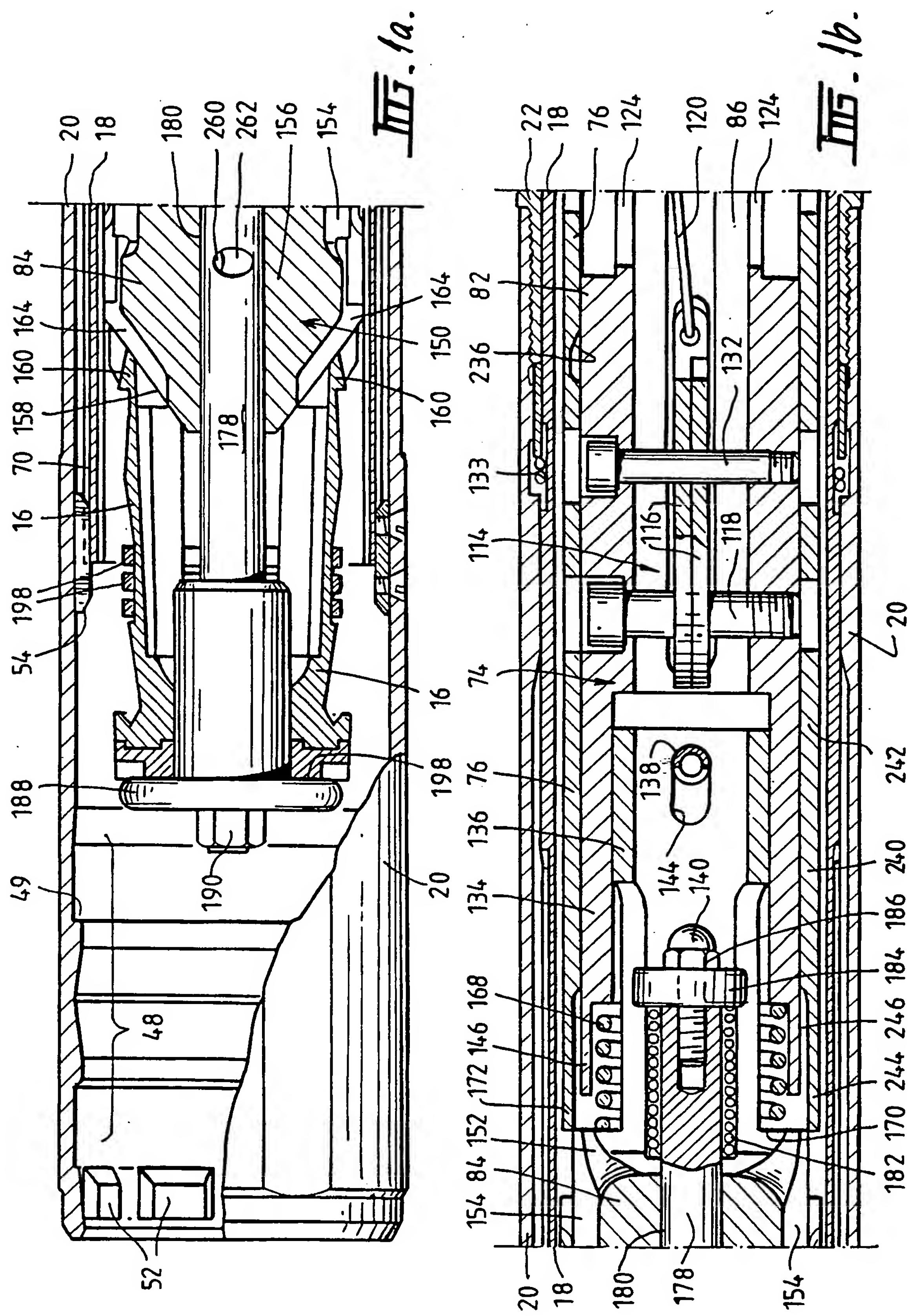
11. A tool according to claim 10, wherein said remote portions comprise bearing surfaces to facilitate continued travel of said apparatus through said hollow member.

12. A tool according to claim 11, wherein each  
5 centering element is in the form of a metal ball.

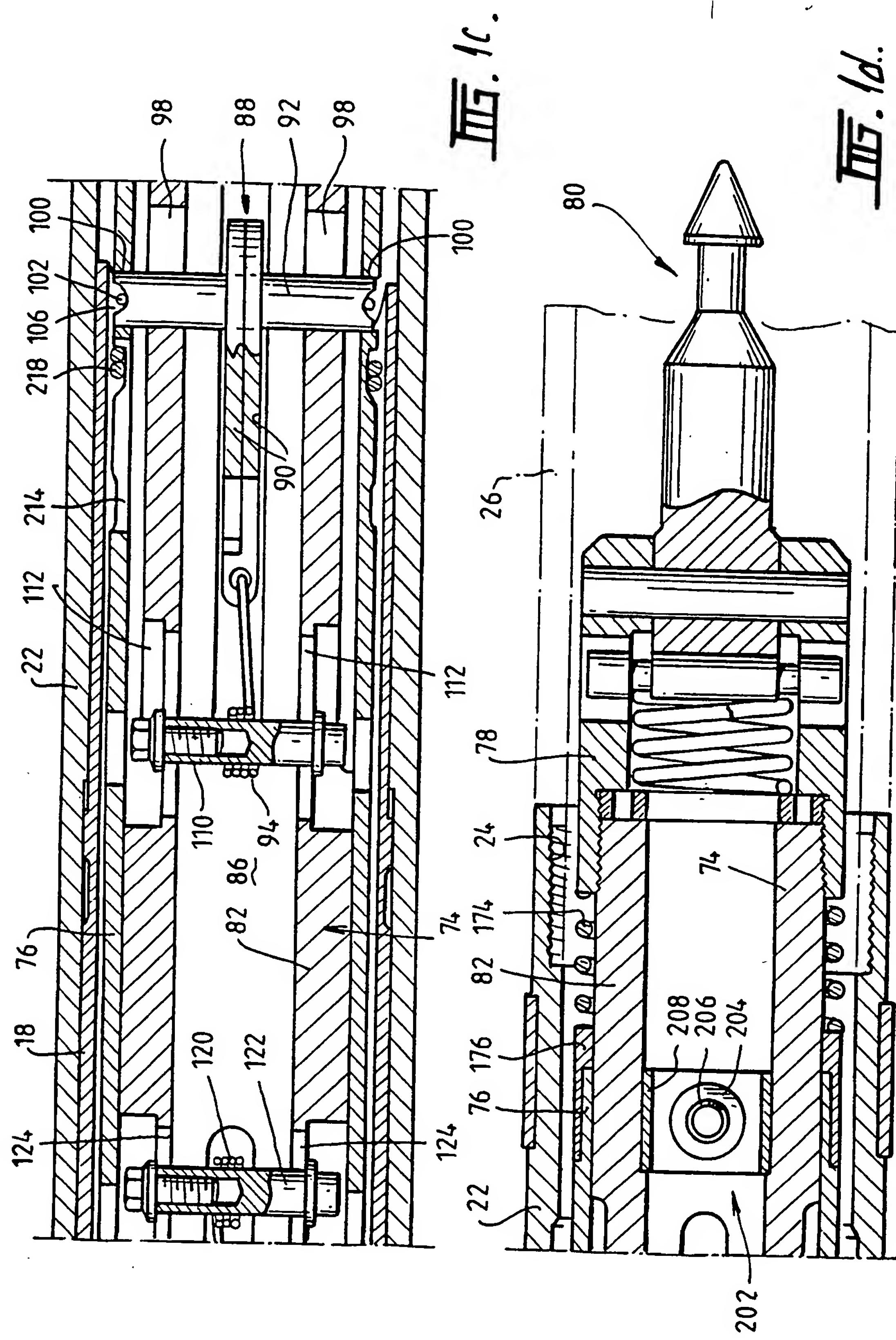
13. A tool according to claim 12, wherein said self centering system comprises three or four centering elements disposed about said apparatus.



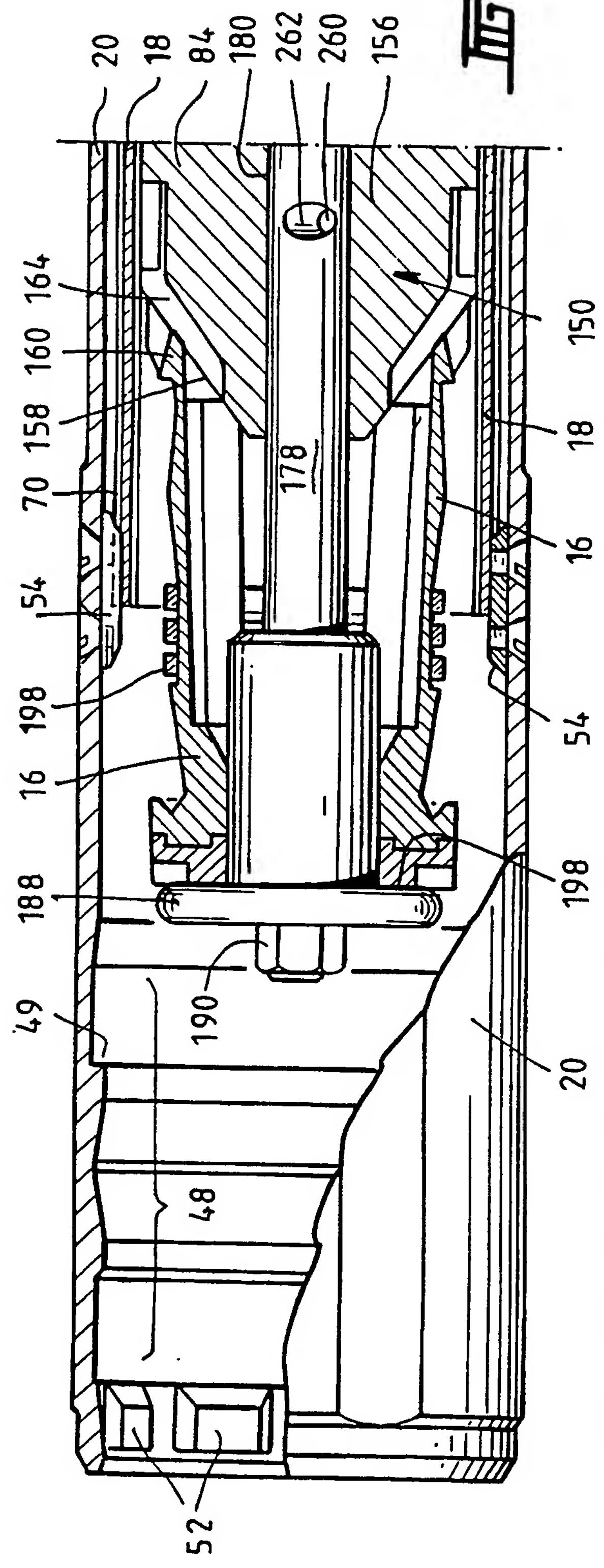
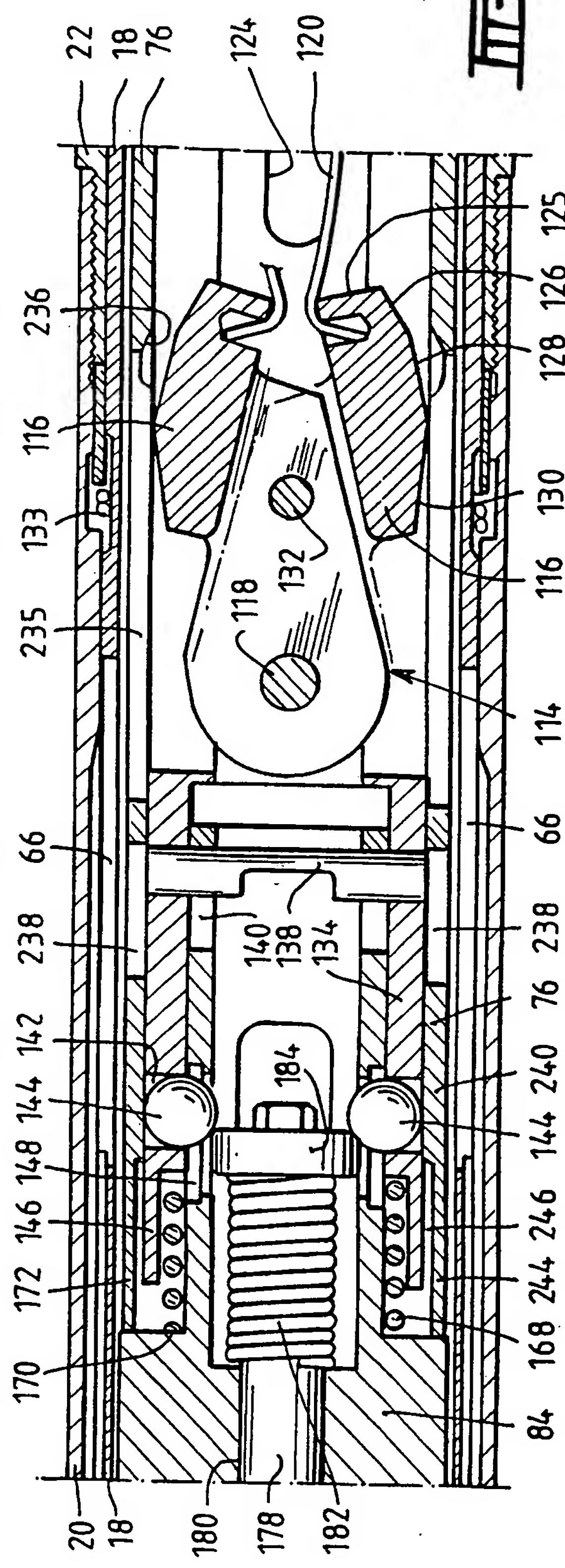
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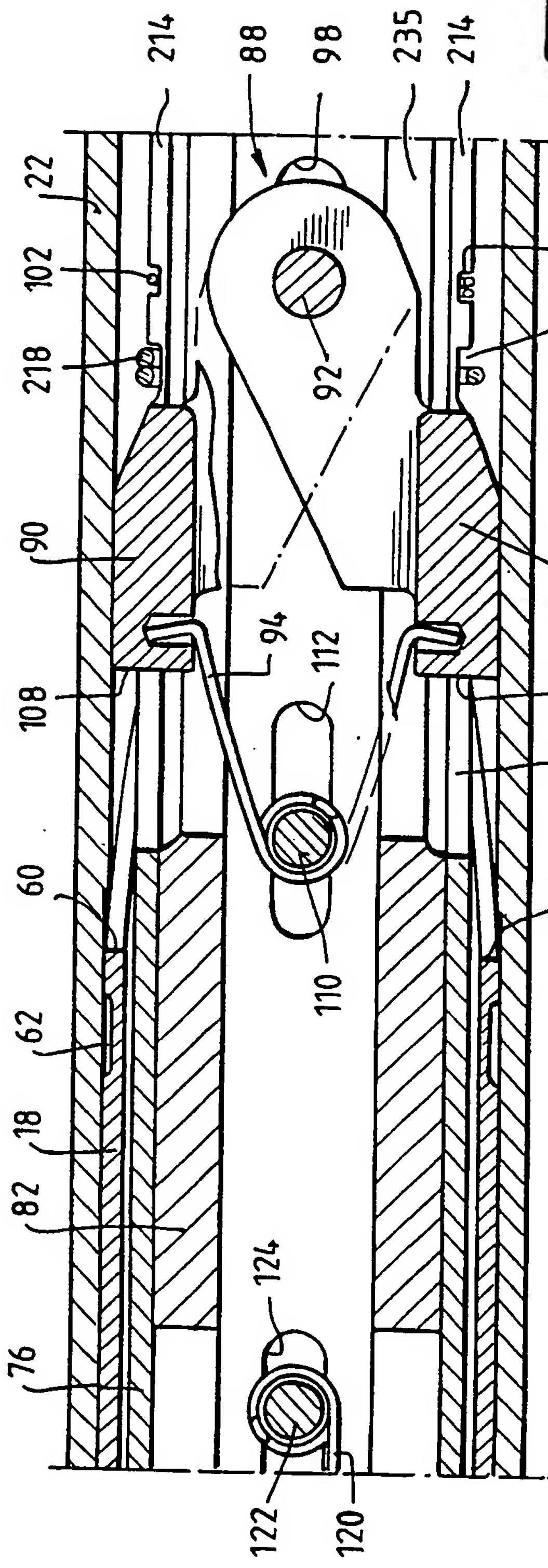
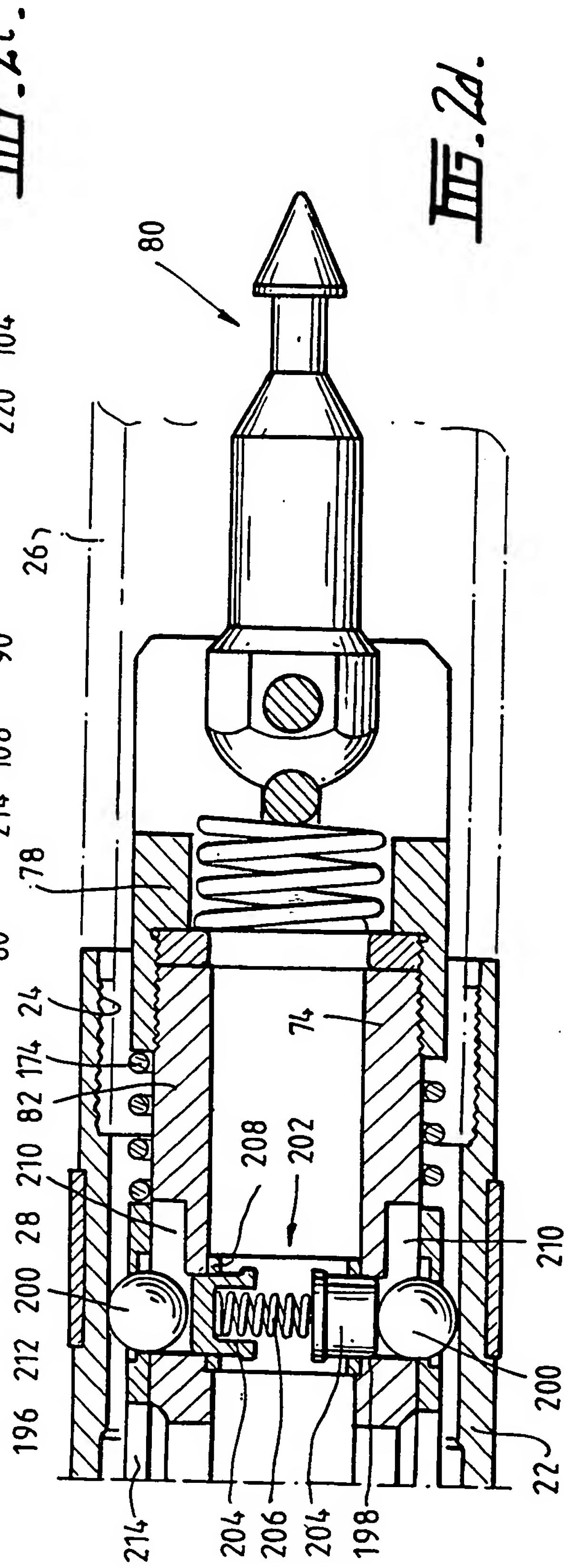
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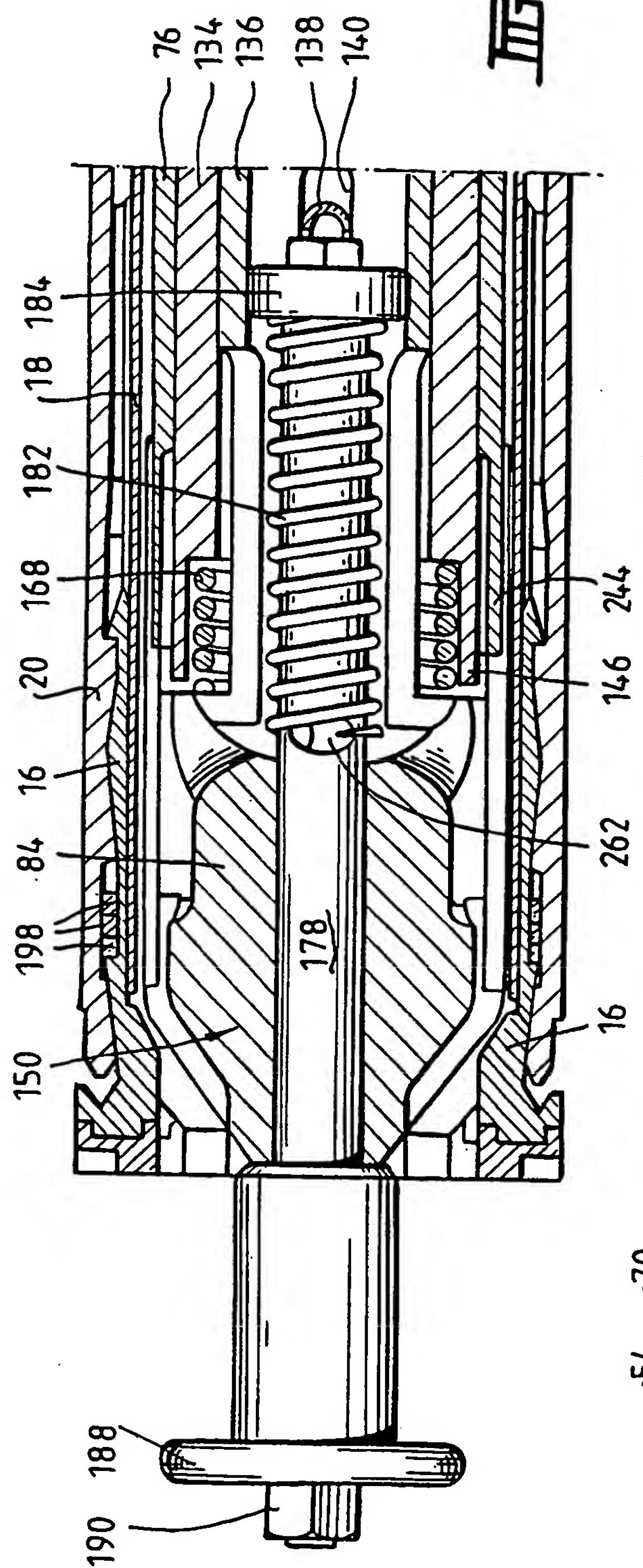
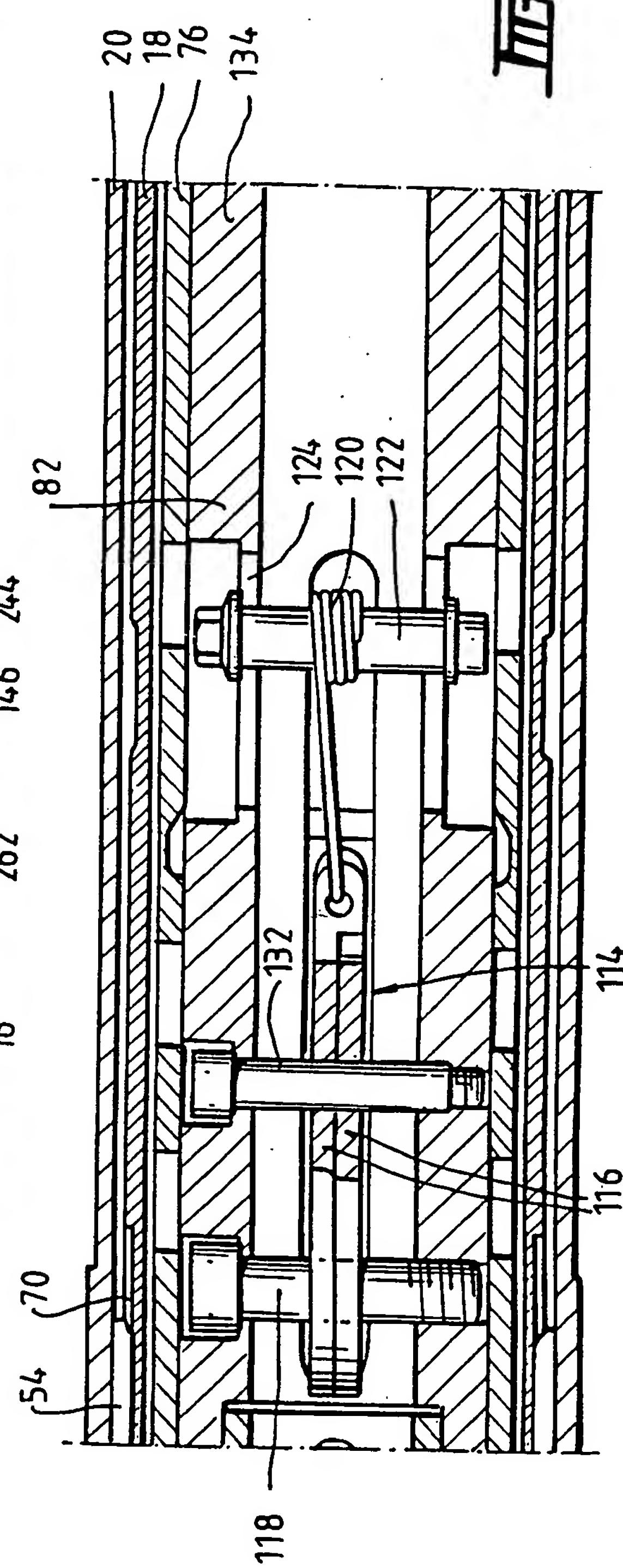
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**III. 2a.****III. 2b.**

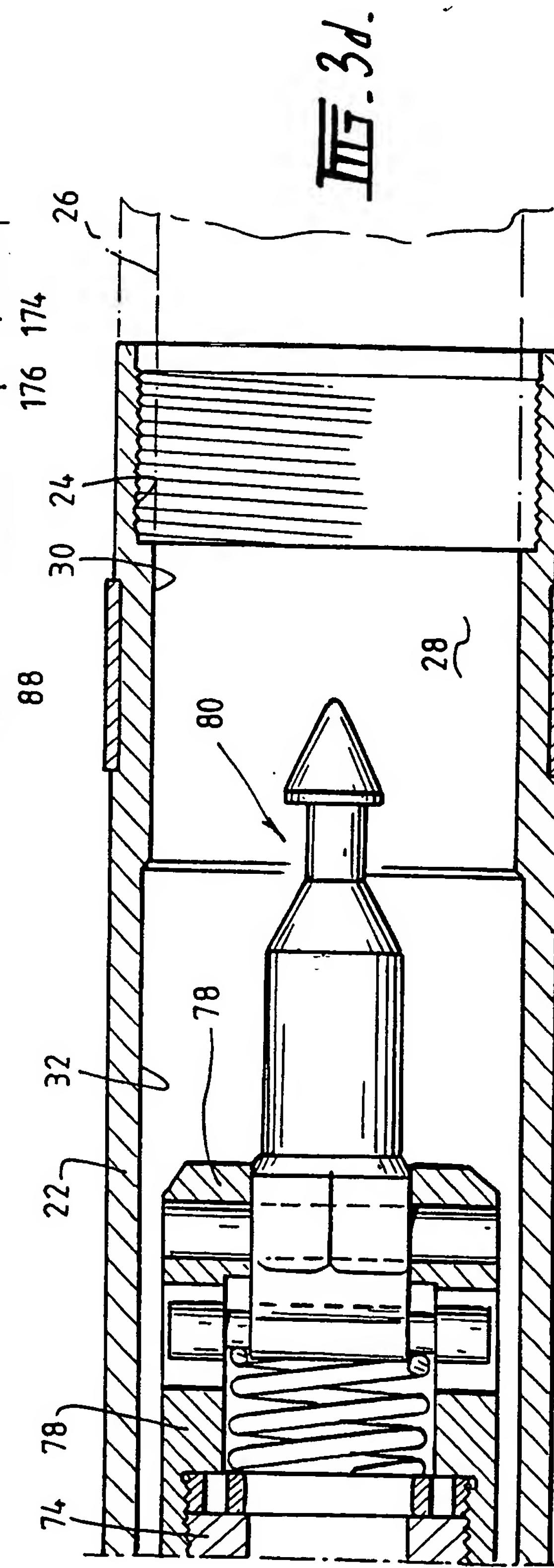
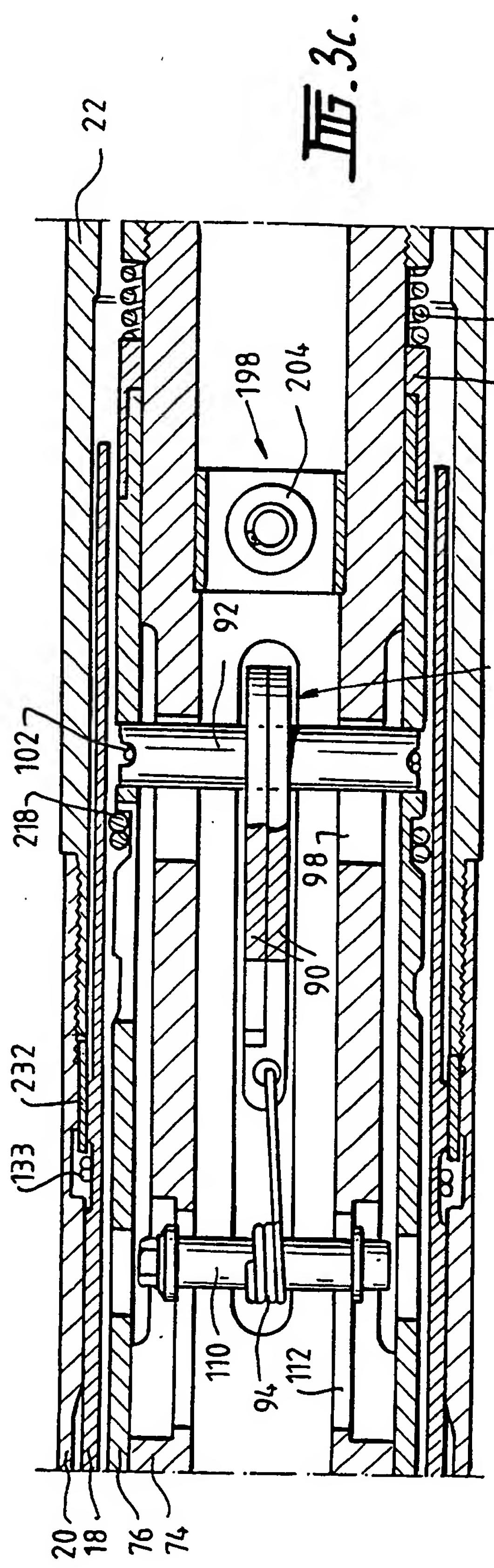
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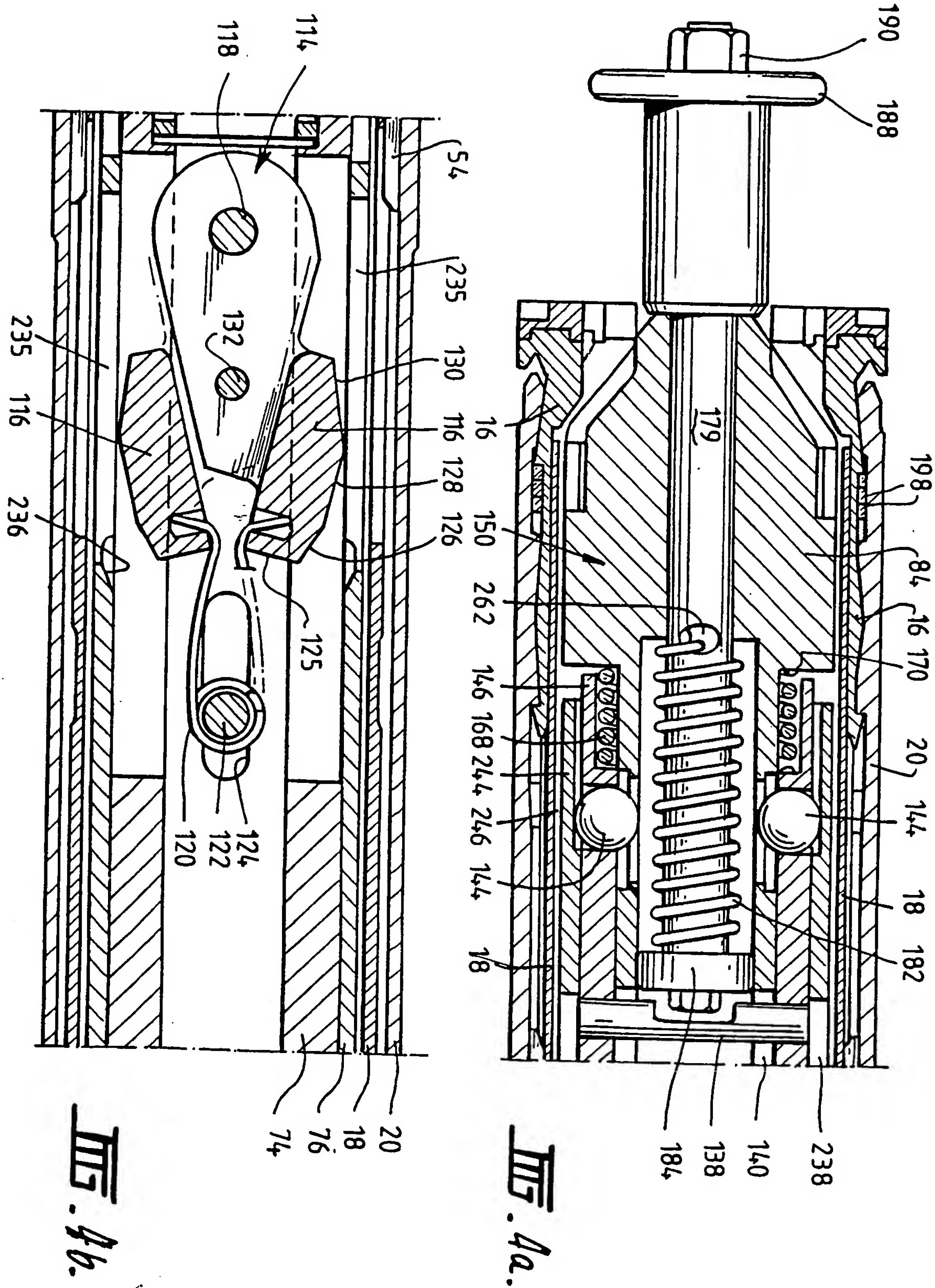
**III. 2c.****III. 2d.**

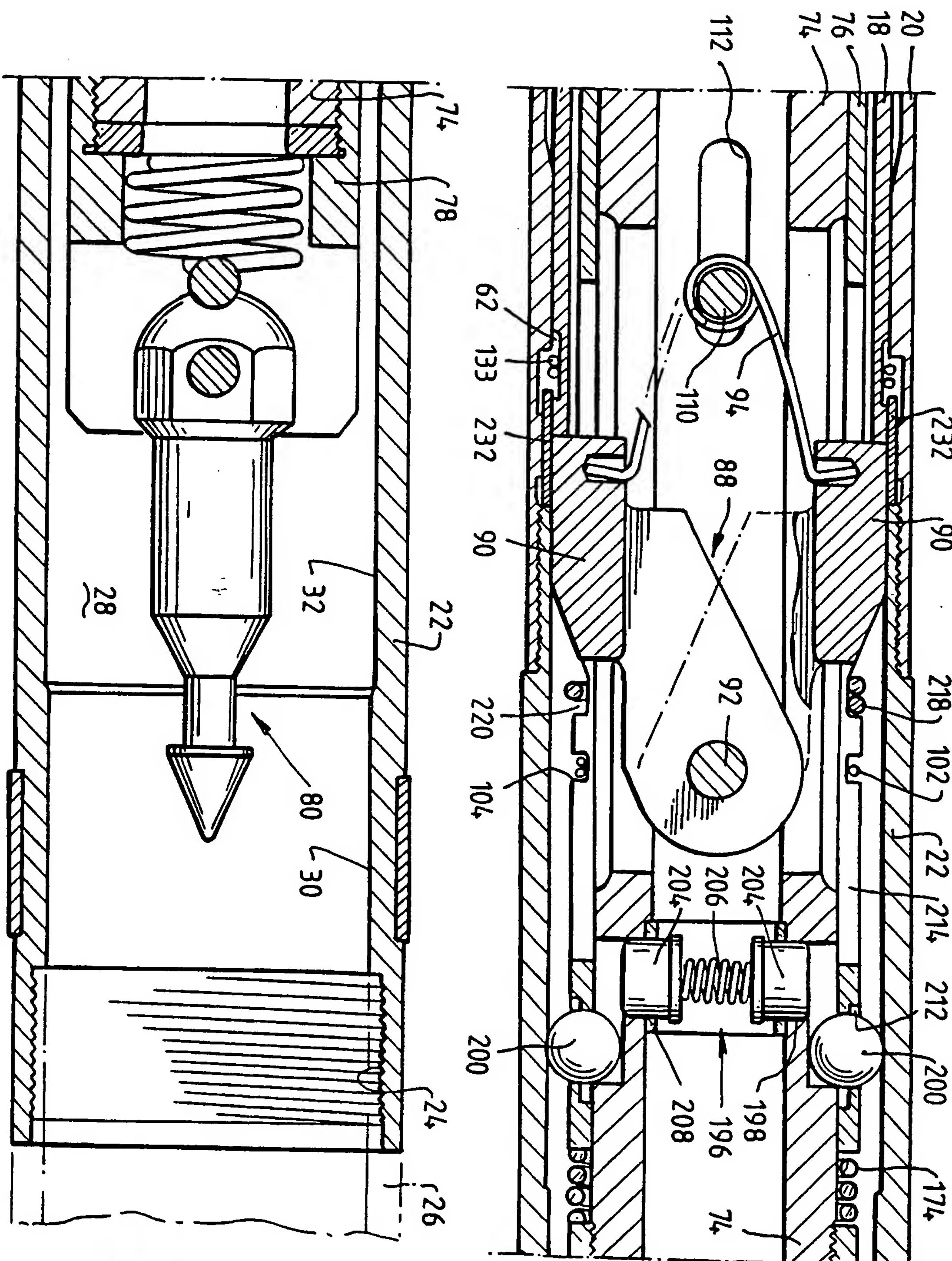
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III5. 3a.III5. 3b.

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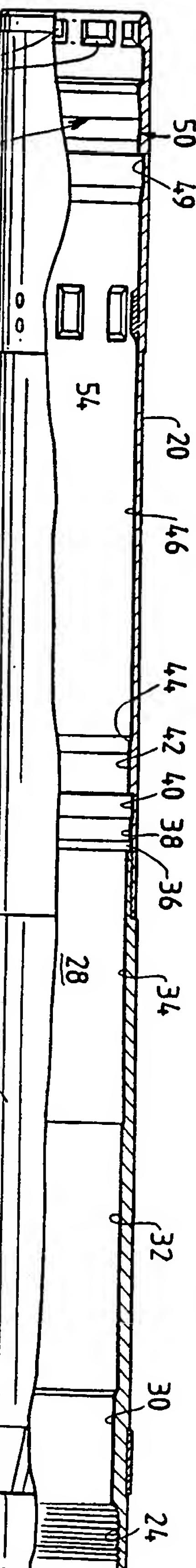




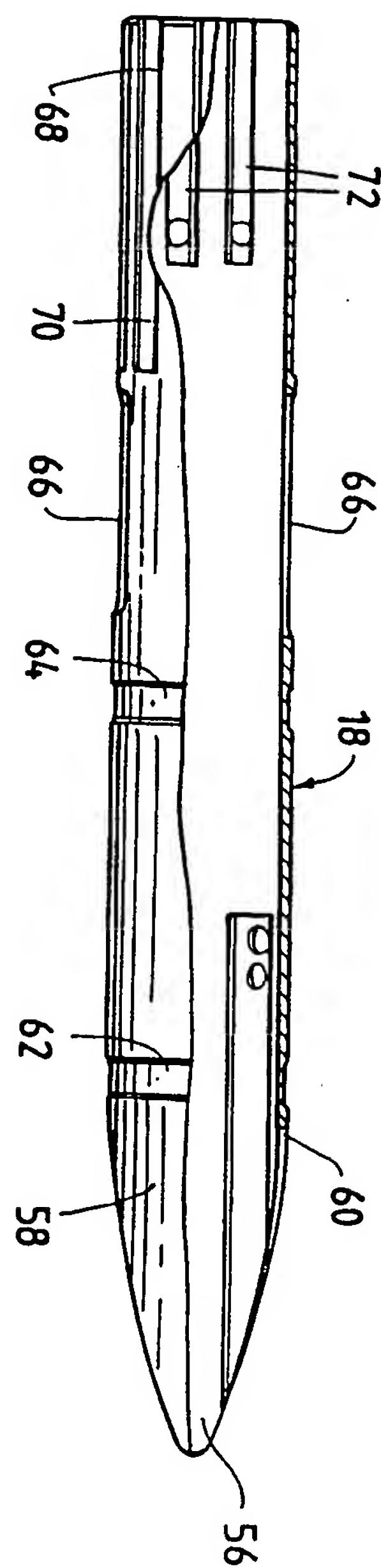
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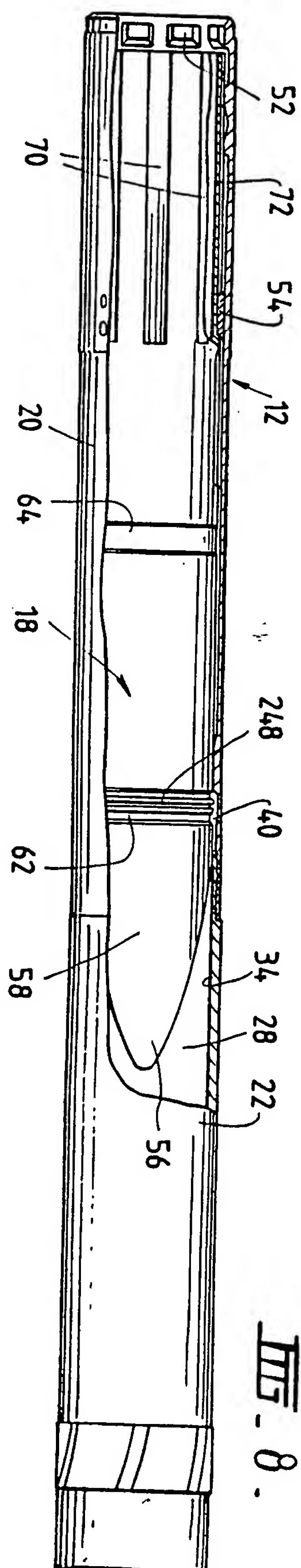
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III. 6.

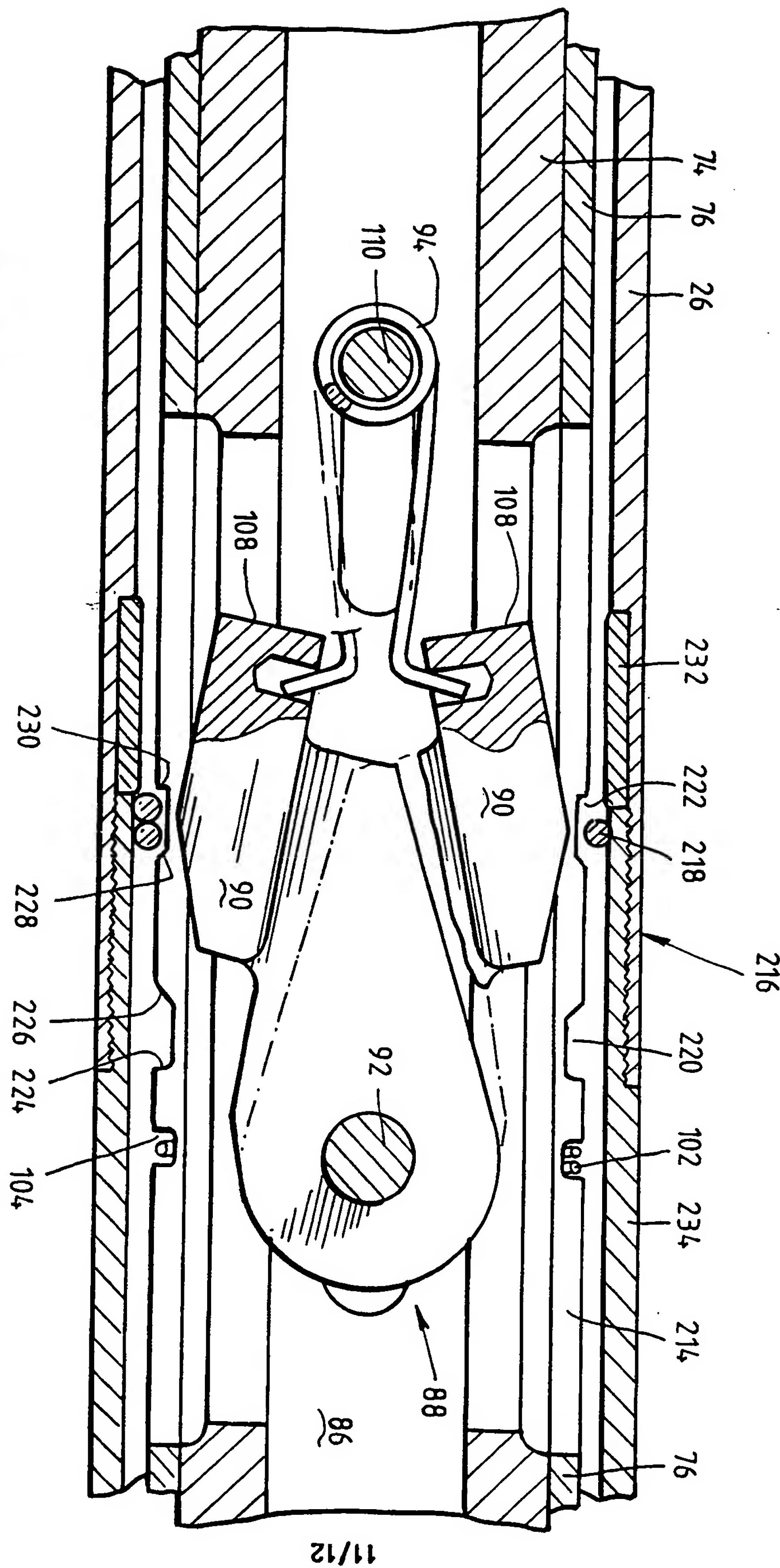


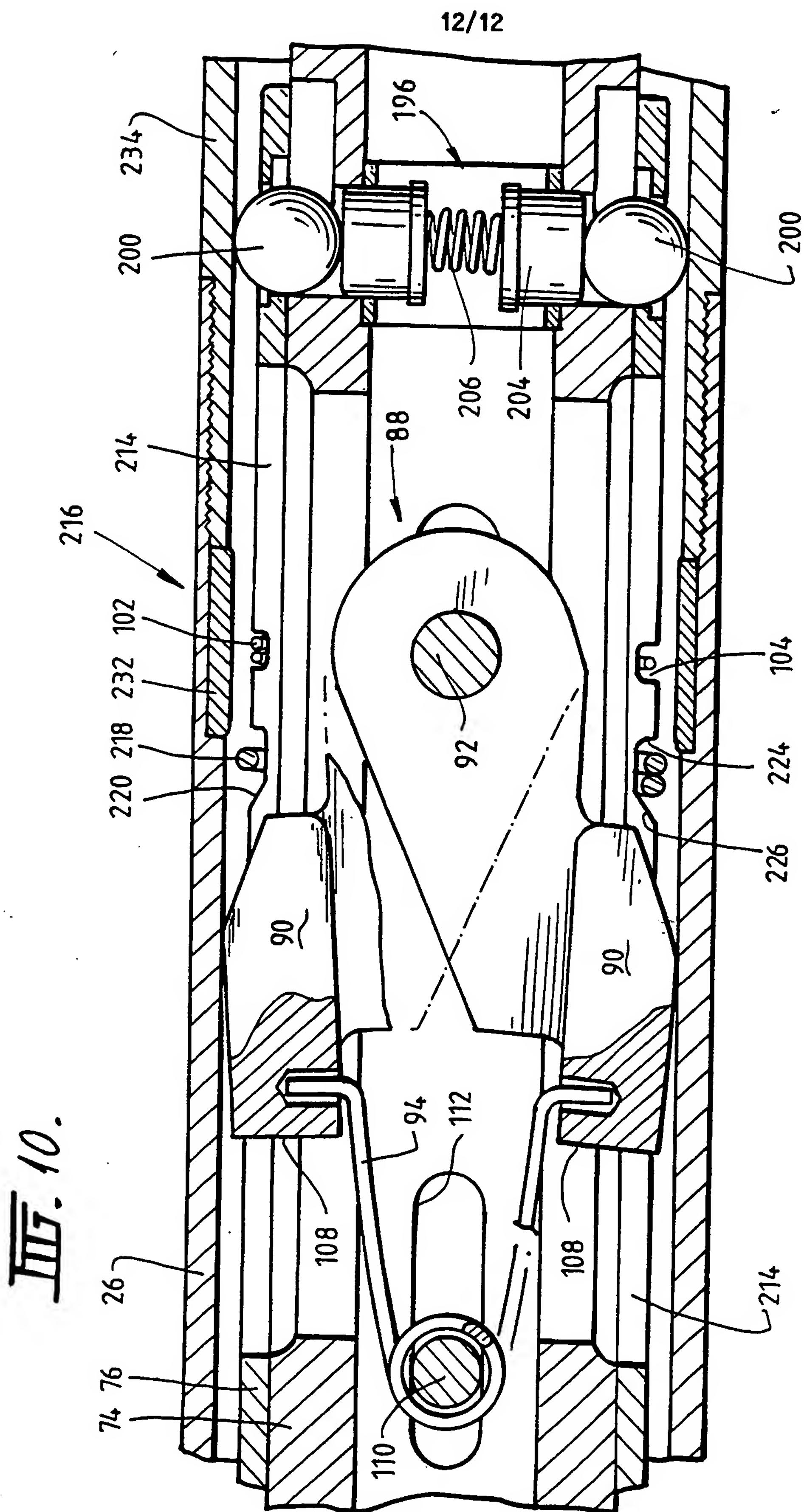
III. 7.



III. 8.

III. 9.





# INTERNATIONAL SEARCH REPORT

International Application No.

PCT/AU 96/00525

## A. CLASSIFICATION OF SUBJECT MATTER

Int Cl<sup>6</sup>: E21B 23/00, 17/10

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)  
IPC : E21B 23/00, 17/10

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched  
AU : IPC as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)  
DERWENT

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	Derwent Abstract Accession No. 56355A/31, Class H01 Q49, SU 571578 A (not given) 6 October 1977 abstract	1-13
X	Derwent Abstract Accession No. 86-012463/02, Class Q49, SU 1162935 A (KRYKH B V) 23 June 1985 abstract	1, 8
X	Derwent Abstract Accession Number 93-056943/07, Class Q49, SU 1719616-A1 (TYUMEN IND INST) 15 March 1992 abstract	1, 8

Further documents are listed in the continuation of Box C

See patent family annex

### \* Special categories of cited documents:

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"O" document referring to an oral disclosure, use, exhibition or other means  
"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention  
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone  
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art  
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Date of the actual completion of the international search  
27 November 1996

Date of mailing of the international search report

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**INTERNATIONAL SEARCH REPORT**

International Application No.

PCT/AU 96/00525

C (Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4190123 A (RODDY) 26 February 1980 column 3 lines 1-58	1, 8
X	US 2964110 A (GARWOOD et al) 13 December 1960 column 2 line 62 - column 3 line 40	1, 8
X	GB 2071736 A (GOSUDARSTVENNY PROEKTNY) 23 September 1981 page 1 lines 51-85	1, 8
A	WO 95/11368 A1 (ANDERGAUGE LTD) 27 April 1995	1, 8
P,A	US 5522467 A (STEVENS et al) 4 June 1996	1, 8

**INTERNATIONAL SEARCH REPORT**  
Information on patent family members

**International Application No.**  
**PCT/AU 96/00525**

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report				Patent Family Member			
US	4190123	CA	1095023				
WO	9511368	AU	79452/94	CA	2174077	EP	723622
		GB	9321695	NO	961574		